

## TOMATOES FOR PROCESSING IN THE 90'S: POSTHARVEST HANDLING.

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### ABSTRACT

Processing tomato industry has a high potential in Spain. Variety testing and mechanization studies and applications have been performed during the last 15 years. Many factors affect the quality and product losses during post-harvest handling which may be classified as: main or external factors: those related to the systems, procedures and devices; and fruit factors: those related to fruit properties. A research project is being carried on in the area of Vegas del Guadiana (Badajoz, Spain) to study these factors and to estimate costs, and to develop improved post-harvest handling practices.

### INTRODUCTION

In Spain, as in other Mediterranean countries, processing tomato industry has a considerable importance, and after a few years of cyclic expansions and decreases, it seems that the acreage and the production are stable, and rather beginning to increase in recent years. Last year (1989), the industries were trying to process as much product as possible, and the acreage raised in some areas over 25% in relation to the acreage of 1986. The reasons for this increase in production are related to the new EC-Spain economic relations, and this topic has surely been discussed in other sessions of this meeting. The fact is that the interest for industry tomato production is in clear expansion in Spain today.

From the total Spanish production (667.000 t), nearly a 65% is produced in Extremadura (Badajoz and Caceres provinces) where the climatic conditions are very appropriate for this product, and also infrastructure is well developed (Ruiz et al., 1983). Most of the production is here for concentrated and juiced tomato, and so all conditions are best suited for mechanization of all the phases of production. This fact was recognized many years ago, and a program for adapting processing tomato production to mechanized systems was started. It is not finished yet. The last phase of the program, now in its second year, is the study of product and quality losses during loading and transportation (Rodriguez et al. 1978, Rodriguez y Ruiz, 1980, 1982, Ruiz 1977, Ruiz and Gil, 1979, Ruiz et al 1980, 1983).

Today, the situation in relation to harvest mechanization is still underdeveloped: the varieties that are planted can be considered as suited for mechanical harvesting, and the cultivation, fertilization, irrigation and spraying practices are mechanized for the most part. Direct seeding is increasing fast, but not yet generalized. Many tests have been carried out, beginning in the 70's, where some eight to ten machines were working, but it was not until last year (1989) that a significant number (15) of mechanical harvesters were purchased, being the outlook for next year that over 60 harvesters will be working in Extremadura. Still, only a very small proportion of the processing tomato is harvested mechanically. Some important adjustments in planting together with varietal scheduling will have to be adopted for efficient mechanical harvest, and also to be able to achieve optimum quality and minimum losses of fruits, as will be discussed later.

#### POSTHARVEST HANDLING: LOADING AND TRANSPORTATION

To be able to analyze the actual situation in this subject in our area, the first thing we decided to do was a questionnaire, that was sent to the ten most important processing tomato producers in different areas of the country. Only a few of them answered it, although fortunately, they rank in the first places, with a combined processing of 50% of Extremadura's total production. From their answers, we were able to draw some very interesting conclusions. A summary of these follows.

### 1. Transportation, loading and unloading.

Most canners purchase their tomato from two different producing areas. Therefore, transport distances are either short (30 km) or long (100-150 km). Their daily processing volumes rank between 300,000 kg per day for one of them, and around 1.5 million kg per day for the rest. At the same time, two different types of tomato transportation are usual (Fig 1): a) tractor-wagon loaded with 23 kg field boxes and b) trucks with 12-14,000 kg containers (gondolas), just as is now generalized in California and other countries. It is interesting to note that this type of bulk transportation is used although the product is harvested manually in boxes; these boxes are unloaded at the side of the fields unto the gondolas, using two different systems: a) tipping the field boxes manually into the gondolas; b) tipping them on fillers, which release the fruits above the gondolas. These loaders discharge the fruits from a height that may be higher than 2 m for the bottom layer. As will be discussed later, this is one important source of damage in the whole transportation system. When mechanical harvesters are used, these load the gondolas directly. The gondolas are sometimes loaded up to 1.8 m deep. (Fig 2).

The growers or the processors don't seem to appreciate great differences in product and/or quality losses between the two transport systems. The reason for changing to gondolas has been the transformation in the unloading system in the processing plants: most have converted to water flumes and channels, and to pools for short-term storage. We consider, however, that these systems of post-harvest handling as they are used today, highly increase product and quality losses.

The average time elapsed between field and cannery is 6-8 hours (min.1, max.24). After unloading in the water channels and checked for damages, they can be in storage for 8-12 hours. Although the data are not very consistent, it seems that a large part of the fruits are subjected to a total lapse time of up to 48 hours from the moment of harvest until processing, with several loading-unloading processes and several temperature (day/night) cycles. This is considered too long a time, as compared to California data (O'Brien, 1980).

## 2. Varieties.

The processors agree mostly in the varieties they select for growing, and they state that they select them : 1st) by earliness (or also lateness); 2nd) by mechanical resistance or "hardness".

## 3. Quality control.

Some processors make a quality control (for damages, rots, etc) in the field, in the cases where they buy the product directly. All of them make quality controls in the plant. They classify for mechanical damage, rots, greens, sunscald, sunburn peduncles; only some of them declare to make industrial quality determinations: (°Brix, pH, Howard index, color viscosity). The samples are taken directly at the entrance water channel for each load (Fig 3).

Our canners were asked to evaluate the importance of several factors on the occurrence of product losses and of quality losses, and not a great coincidence was observed among their answers. Some aspects are interesting to be pointed out: they give a first importance to maturity level of the fruits, in connection to variety characteristics; after that, they rank together, as equally important, transportation and loading-unloading procedures, and lapse time between harvest and processing.

From these answers we see that the different growers and processors have a very different appreciation of the factors that influence their product and quality losses, and that systematic studies are needed to establish these factors, and to evaluate them economically. Starbird and Ghiassi (1986) made a simulation modeling study for optimizing design and performance of processing tomato plants; one of their main conclusions is that "raw product quality has a significant effect on the profitability of the plant", and that this effect requires further study to be fully exploited.

The cost of transportation declared by our processors varies between 0.010 pta/kg.km to 0.6 pta/kg.km. Other growers prefer to estimate the transport cost as an average value per kg transported: 1.2 pta/kg.

All agree that complete mechanization of production and harvest is an important factor to improve quality. Analyzing this point, the conclusion is that mechanical seeding and mechanical harvest assure a better scheduling of harvest dates, so that the product can be harvested at an optimum stage, being this one of the most important factors on quality preservation.

#### STUDY OF FACTORS INFLUENCING PRODUCT AND QUALITY LOSSES.

It is interesting to study the factors which may have an influence on the quality of the product before it gets into processing. Only a few studies have been carried out in the past, looking mainly to the losses of fruits during harvest and transport to the processing plant. O'Brien (1980) established a loss of 12% of the product due to various factors. We decided to establish here two groups of factors:

A) "main factors or external factors" are those related to the systems, to the procedures or to the devices used in postharvest handling of processing tomatoes:

- excessive load heights which cause impact damage
- excessive load depths, which cause compression damage and loss of juice
- excessive acceleration of the fruits at filling
- time elapsed between harvesting and processing
- distance of transportation
- temperature of the fruits, related to time of the day at harvest.

These factors can ( and have to ) be studied in each case, for each plant, and systems can be devised to reduce product and quality losses. Quantification of the economic importance of the real losses, and of the returns that can be obtained by the establishment of improved procedures are necessary. In the case of our growers and processors, this has not been approached yet.

The second group of factors influencing the level of product and quality losses in processing tomatoes relate to the fruit itself.

B) "fruit factors" are the inherent physical properties of the fruits, and also of the plants, which are varietal in nature.

Physical properties of fruits of processing tomato varieties.

During more than 7 years, starting 1975, testing of the mechanical resistance of processing tomato varieties was carried out in the Laboratory of Physical Properties of Agricultural Products (Universidad Politécnica Madrid) and the Extremadura Agricultural Extension and Expt. Service (today SIA), in Don Benito, Badajoz. Over 100 varieties were tested, and their resistance was determined by :a) deformation with a steel-ball to 2mm, and measurement of the force; b) deformation and puncture with a cylindrical dye of .5 mm of diameter; c) free-fall tests to determine the correlation of laboratory measurements and real damage. From these studies, it was concluded that:

1) with the puncture test, both firmness and skin resistance could be estimated;

2) the most resistant varieties are those with a highest puncture resistance, and not necessarily the most firm; resistant skin, and elastic skin and hypodermis (first cell layers below the skin) were the most desirable conditions;

3) after a few years, most recommended varieties for processing tomatoes possessed good resistance characteristics ;

4) resistance parameters show a high variability between fruits, even at the same conditions and coming from the same plot; Rodriguez-Sinobas et al (1986) showed that parametric analysis were most appropriate for analyzing these data and that, doing so, fairly consistent results can be obtained, although the variability always remains. The reason for this variability must be related to agronomic factors; some varieties, however, always showed a greater variation in these characteristics than others.

5) size, shape and skin discontinuities are also important fruit characteristics in relation to mechanical resistance.

All the tests were performed using vine ripened fruits in full maturity. Overripe fruits show usually lower resistance. This means that the presence of a high proportion of overripe fruits in a harvest will be a most important source of losses. Therefore, scheduling of planting and harvest, using a well

established variety program, and in combination with mechanical harvest appears as the first factor to be taken into account to reduce product and quality losses in processing tomato production.

These physical properties, are affected by several external conditions, and these have to be considered "factors" also, because we can influence on them; they are well known:

- irrigation: quantity, and time of discontinuing it before harvest
- soil preparation
- nitrogen uptake, in relation to: a) plant growth and b) to its level in the fruits
- other elements: potassium, calcium, magnesium
- growth regulators

A factor that appears lately as having a potential influence in the quality of tomato fruits refers to the chemical constituents. A few studies of this kind have been carried out, most of them in tomatoes for the fresh market and other fruits and vegetables. They show that, for example, a higher content of potassium increases the resistance and the quality of tomato fresh fruits (Hardt et al 1979). Calcium, potassium and magnesium uptake by the tomato fruits varies considerably with the quantity present in the soil (Rodriguez, 1985, Mullins and Wolt, 1983). This factor should be also taken into consideration in an interdisciplinary study of the improvement of quality and reduction of losses of horticultural products.

Frost and Kretchman (1987) made recently a study of the effects of growth retardants with the aim to improve ripening uniformity and yield, by reducing late-season growth. Their results, although promising, are not conclusive yet.

#### STUDY OF PRODUCT AND QUALITY LOSSES IN THE AREA OF VEGAS DEL GUADIANA

Two years ago a study was initiated to evaluate product and quality losses in postharvest handling procedures in the producing area of Vegas del Guadiana in Badajoz (Extremadura, Spain). The objectives of the study were to get conclusions about the most important factors affecting the losses, and to design new systems to improve quality and diminish losses. Following aspects are being studied:

a) possibilities of damping the impacts that the fruits suffer at falling

b) height of fall of the fruits into the container and its influence on the observed losses

c) design of a transformed filler to reduce height of fall

d) depth of load in the containers and its influence on losses during transportation; depths used are 1, 1.2 and 1.4 m.

e) transportation distance: 30, 80 and 150 km

f) influence of variety: H9889, UC82, Rio Grande (Rio Fuego), Yuma.

g) times elapsed between: harvest and loading into container (1 to 3 in Figure 1); transport duration (gondola in motion, 3 to 4); waiting time in the cannery until dumping (4 to 5).

The effects of these factors are studied on following variables:

1)) mechanical damage on the fruits: weight and percentage of damaged (skin cuts) and broken fruits (class III, visible loculus, O'Brien 1980). Samples of fruits are taken right after harvest, after loading, after transportation and at unloading in the cannery, and rated for damage.

2)) juice and pulp losses in the containers: the gondolas were specially made with a drainage system (Fig 4), so that all the free liquid was drained and weighed before unloading each gondola at the cannery.

3)) total weight loss of the gondolas during transportation

4)) industrial quality indexes: juice extract soluble solids (% Brix by refractometer); Howard index

During the last two years (1988 and 89), hundreds of samples have been studied during the whole harvest time (August -September).

The first year, the main task was to test the gondolas and improve their drainage system. Also, from the analysis of the data, a very significant effect was observed of the growing fields. The differences in damage and losses measured were greater for different fields than for different loading and transportation procedures, with a very high variability. This year, all these factors were taken into account for the tests, which were finished only a couple of weeks ago.



Also, a loader-filler was designed and constructed that is curved at the top and has a variable slope, so that at filling, the height of free-fall is diminished. This filler was used to test damage in fruits resulting from free-fall on the container. Samples of 100 fruits were dropped with the filler onto a container, from different heights: 70, 110, 150, 190 cm Figs 5 and 6. Evaluation of damages was made in each sample by a set of sorters. The increase in skin-damaged and broken fruits increases up to 200% in some cases, with a significant effect of variety, and no significance of the type of bottom used; steel, foam or plastic-covered foam.

## CONCLUSIONS

An everyday more important challenge of vegetable and fruit production is "high quality and reduced costs". After reviewing the factors that affect quality and product losses in processing tomato post-harvest handling, it appears necessary to perform interdisciplinary studies to be able to focus on all factors (biological, physical, mechanical, economical,...) in a combined effort.

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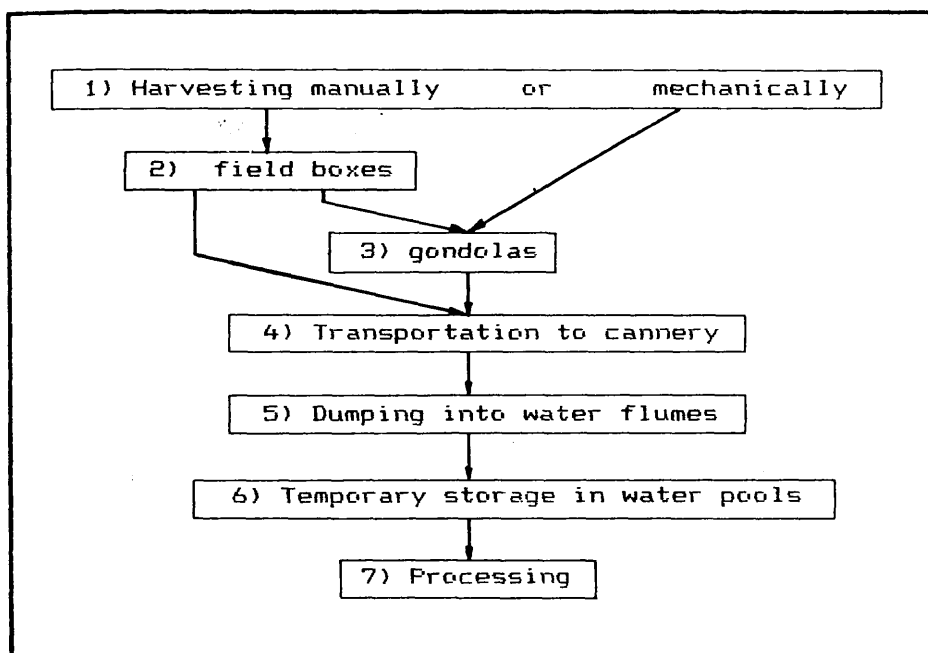


Figure 1. Postharvest handling system for processing tomatoes.

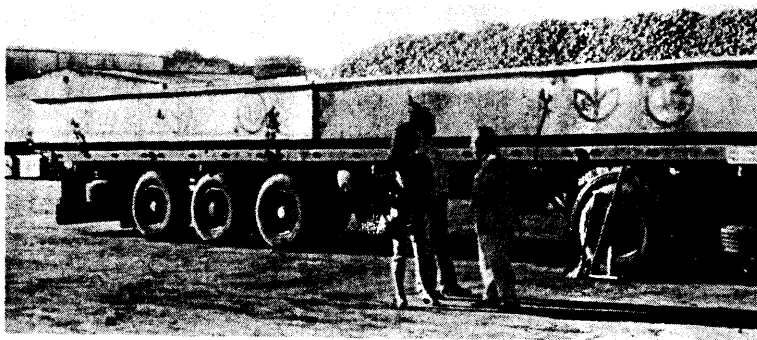


Figure 2. Tomatoes are bulk loaded in large containers (gondolas).  
Note the excessive load of this container.



Figure 3. Samples of each load are tested for damaged fruits and  
losses, from the water flume at unloading in the processing  
plant.

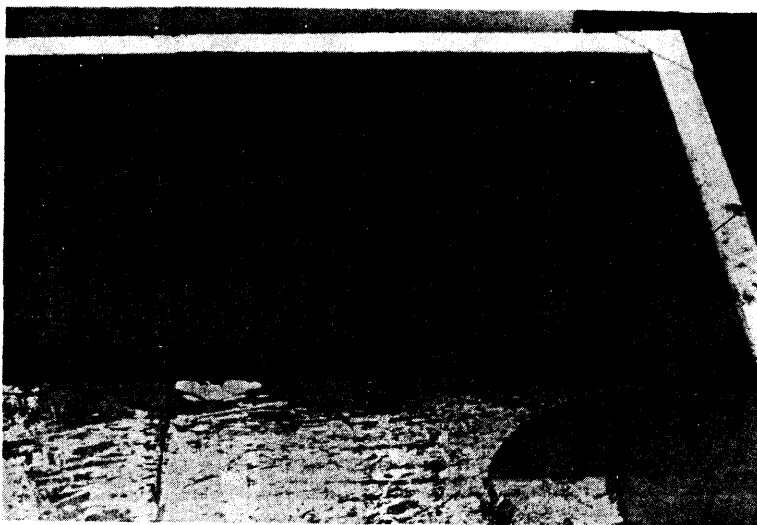


Figure 4. The bottom of the containers used in the tests was prepared to be able to get samples of the drained juices before unloading in the processing plant.

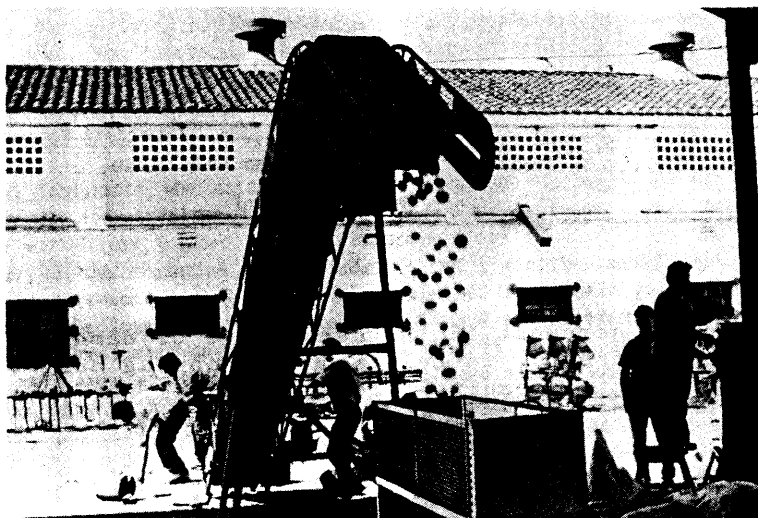


Figure 5. Samples of fruits are unloaded unto testing boxes, from different heights, and all fruits are examined for damages.

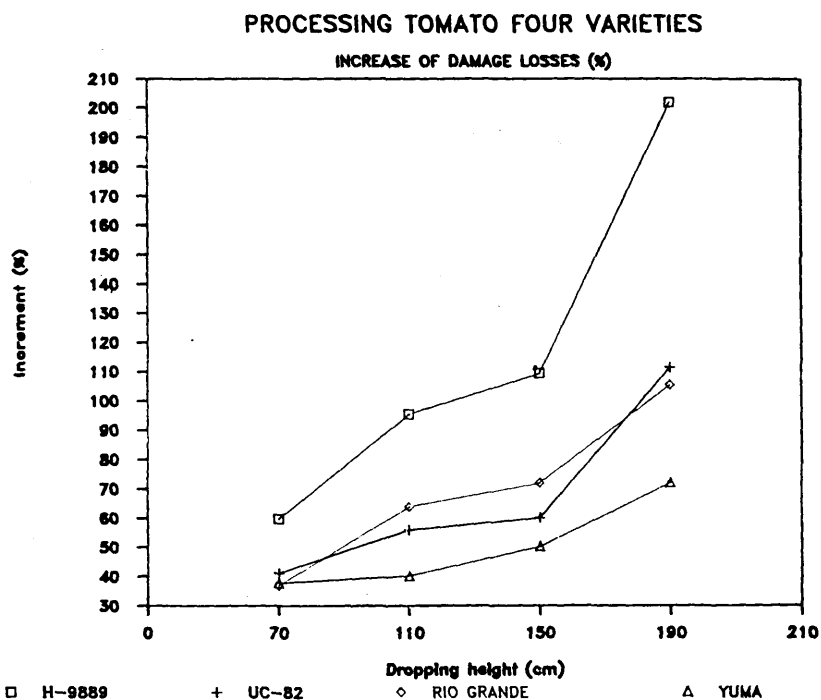


Figure 6. Increment in the percentage of damaged and broken fruits, in relation to dropping height and for four processing tomato varieties.